
INSTRUCTION MANUAL

Model T-5

MP MASTER



MA29053



Tenney
ENGINEERING, INC.

The Largest and Most Experienced Manufacturer of High Technology Environmental Test Equipment

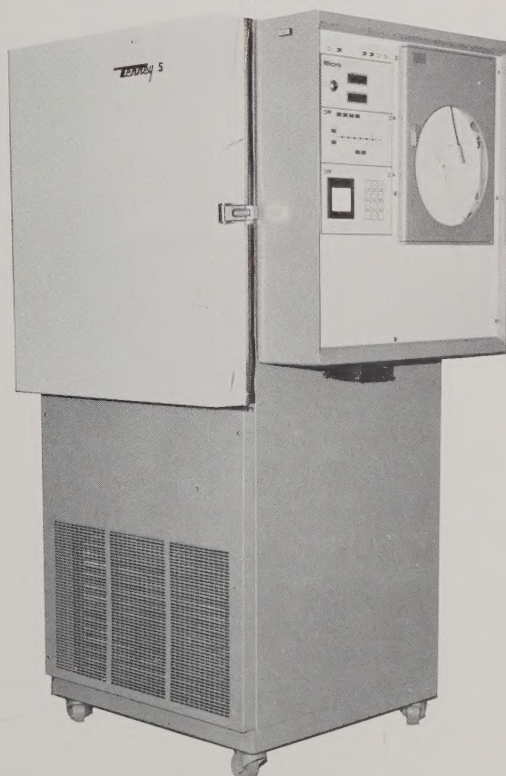
Tenney-5

Temperature & Temperature/Humidity Test Chambers

FEATURING SEVEN PERFORMANCE VARIATIONS

MODEL TR5-1893 – 18°C to 93°C with humidity
MODEL TR5-34200 – 34°C to 200°C with humidity
MODEL TR5-73200 – 73°C to 200°C with humidity
MODEL TR5-80200 – 80°C to 200°C with humidity
MODEL T5-34200 – 34°C to 200°C
MODEL T5-73200 – 73°C to 200°C
MODEL T5-80200 – 80°C to 200°C

The Tenney-5 series of environmental test chambers is widely used in test programs requiring the simulation of straight temperature or temperature combined with humidity. The series is perfectly suited for use in quality assurance and reliability programs for electronic, military, pharmaceutical and laboratory testing, as well as in production processes. Seven performance variations permit the selection of a standard unit to meet a broad range of test requirements. The Tenney-5 series offers a full five cubic foot workspace volume in a compact, completely self-contained package occupying a minimum of floorspace. As specified, chambers are mechanically refrigerated by means of a single stage or cascade system utilizing non-toxic and non-explosive refrigerants.



Tenney-5 shown with
unitized instrumentation
and control panel
and available options



CONSTRUCTION

The Tenney-5 Series utilizes a heavy gauge, reinforced heliarc welded stainless steel interior for strength and durability. The insulated workspace area is constructed with mass type fiber glass for low heat transfer and Vapor-Weld walls for impermeability to moisture.

Heavy gauge exterior provides an attractive two-tone blue washable finish. Units feature a 2" (5cm) diameter accessory port with plug and a six foot grounded electrical cord with plug. All wiring connections are made at numbered terminal strips and are in accordance with NEC. Full opening lap-type door, with two concentric thermal gaskets for vapor-tight sealing, is provided.

STANDARD FEATURES

- TennTrol, LED displays, with push-to-set adjustments in °C and direct RH for humidity models.
- Vapor-Flo® (humidity models), a humidification system which precisely regulates moisture in the chamber by controlling vapor migration between the humidity generator and the cabinet.
- Tenneyairesweep, a system which uniformly conditions the environment within the insulated enclosure. The system draws air from near the bottom of the workspace and conditions it to the proper temperature and humidity. The air is discharged through a grille work at ceiling level of the chamber and a uniform air flow pattern is achieved throughout the chamber.
- Hermeticool®, an accessible hermetic refrigeration system incorporating accurately calibrated capillary tubes in lieu of mechanical expansion valves.
- A solid state SCR, fast response, platinum resistance sensor temperature controller. Models with humidity incorporate separate controllers for dry bulb and direct RH (HumiTenn).
- HumiTenn (humidity models only) a signal conditioner that accepts dry and

wet bulb signals and converts them to a direct RH input for any standard Tenney controller.

- LogiTenn, a logic module that automatically selects refrigeration, heating and humidity modes, as required, to achieve the desired chamber environment.
- Unitized instrumentation and control panel.
- Control circuits that provide quick response to load demands and minimize control oscillations.
- Nichrome heaters, designed to provide rapid response to instrument demand.
- Cascade refrigeration system (for -73°C or lower capability models only). Sequential starting of compressors reduces starting current.
- RFI free instrument.
- Circuit breakers are used throughout.
- Tenney one-year warranty.

OPTIONAL FEATURES

- MicroTenn®, microprocessor programmer-controller, automatically signals chamber controls to perform time-related programs. Replaces cams and punched tape devices.
- TempGard® II temperature alarm

system. Guards against out-of-tolerance temperatures in a test chamber. Protects chamber and test specimen.

- Recording instruments.
- Manual window wiper.
- Thermal pane viewing window.
- Interior light.
- Thermocouple or electrical terminals.
- Special connectors.
- Additional or larger ports, or glove ports.
- Removable shelves.
- Mineral deionizer.
- Sump tank (1 or 5 gallon).
- Humidity water recirculator.
- Automatic CO₂ or LN₂ booster system.
- Recessed, heavy duty casters.
- Remote instrumentation console.
- Pressure taps and gauges.

SAFETY FEATURES

- Concealed air circulating fan.
- High temperature cutout protects chamber.
- Freeze protection on wet wick pan and wet wick controls (with humidity).
- Low water protection on Vapor-Flo® unit (with humidity).
- Humidifier fail safe (with humidity).
- Grounded electrical cord and plug.

All Tenney-5 Chambers are available on a direct leasing basis.

SPECIFICATIONS AND PERFORMANCE DATA

MODELS		TEMPERATURE/HUMIDITY				TEMPERATURE ONLY		
		TR5-1893	TR5-34200	TR5-73200	TR5-80200	T5-34200	T5-73200	T5-80200
Control Tolerance		± 3°C	± 56°C	± 56°C	± 56°C	± 56°C	± 56°C	± 56°C
Fuse Requirements at 230V, 1PH, 60Hz (other voltages optional)		20 A	25 A	25 A	30 A	20 A	25 A	30 A
Refrigeration Size		1 HP	1 HP	2 HP	3 HP	1 HP	2 HP	3 HP
Temperature Range		-18°C to 93°C	-34°C to 200°C	-73°C to 200°C	-80°C to 200°C	-34°C to 200°C	-73°C to 200°C	-80°C to 200°C
Temperature pull down time in minutes from 24°C ambient	to -7°C	25	15	10	5	15	10	5
	to -18°C	40	40	15	10	40	15	10
	to -34°C	-	90	20	15	90	20	15
	to -54°C	-	-	30	25	-	30	25
	to -73°C	-	-	50	40	-	50	40
Temperature heat up time in minutes from 24°C ambient	to 66°C	15	15	15	10	15	15	10
	to 93°C	30	20	20	20	20	20	20
	to 200°C	-	50	50	40	50	50	40
Capacity for holding live loads (dissipation in watts during temperature performance)	at 10°C	400	400	600	1200	400	600	1200
	at -7°C	300	200	600	1000	200	600	1000
	at -18°C	150	100	600	900	100	600	900
	at -34°C	-	50	500	700	50	500	700
	at -54°C	-	-	350	500	-	350	500
	at -73°C	-	-	100	300	-	100	300
Dimensions (W×H×D)	Interior	21"×25"×16½" (53cm×64cm×42cm)				21"×20"×21" (53cm×51cm×53cm)		
	Exterior	37"×72"×31" (94cm×183cm×79cm)				37"×72"×31" (94cm×183cm×79cm)		
Humidity Performance		20% to 98% in the dry bulb range of +20°C to +85°C, limited by a +3°C dew point.						
Shipping Weight, uncrated (approx.)		800 lbs. (363 Kg)				800 lbs. (363 Kg)		

Control of conditions is as indicated on instrumentation furnished with chamber. Minor performance variations with window and accessories. Performance data is based on ambient temperature of +24°C at sea level, on 60 Hertz operation. For 50 Hertz operation, performance will be approximately 17% less. Under certain programming conditions, stated rates of change may vary.

In line with our policy of continual product improvement, Tenney Engineering, Inc. reserves the right to incorporate and use equipment and material to conform with the latest design of its products and in keeping with the specifications of this equipment. Tenney chambers are designed to meet MIL-SPEC humidity tests. Other humidity tests are available on request.

TENNEY ENGINEERING, INC.
1090 SPRINGFIELD ROAD
UNION, NEW JERSEY

OPERATING INSTRUCTIONS

FOR

MODEL - T-5 With MicroTenn

Basic Manual

Bulletin No. 106

Refrigeration Compressor Data Sheet

Drawings

MicroTenn Operating Instructions

"Operation of A MicroTenn-Equipped Chamber"

TABLE OF CONTENTS

SCOPE	1
INSTALLATION	1
WATCH THAT LINE VOLTAGE	2
PREPARATION FOR USE	3
OPERATE THE CHAMBER AS SOON AS IT IS RECEIVED	3
OPERATING WITH AN ACTIVE HEAT LOAD	4
PREVENTIVE MAINTENANCE	5
IN CASE OF TROUBLE	6
PARTS IDENTIFICATION	8
PARTS REQUISITIONING	8
DANGER	8
CAUTION	8
WARNING	8



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SCOPE

This manual covers installation, use and care of Tenney MicroTenn-equipped T-5 Temperature chambers with single push button mode switch. These test facilities are generally described and pictured in accompanying bulletin #106.

MicroTenn operating instructions and a manual explaining the application of MicroTenn to the chamber are forwarded with this instruction kit. Please read the MicroTenn material before operating the chamber.

INSTALLATION

Specific drawings applying to your individual chamber accompany this manual. Look them over carefully before installing the chamber. The drawings tell you what power is required and what fuses to use. If your chamber has a water-cooled refrigeration system, the drawings will specify how much water is required and will show where to make your hook-up. These drawings also carry parts lists useful to maintenance and service personnel.

Your chamber is completely assembled, charged, tested and ready to operate. Install it where the ambient does not exceed 100°F or fall below 60°F. The unit may be operated in ambients outside this range. However, its performance is rated at 75°F.

Proceed as follows:

Set the chamber so there is a foot or more free space all the way around for ventilation.

Be sure the floor can carry the weight. Depending upon size of refrigeration and number of accessories, your T-5 weighs something under 900 pounds.

Level the chamber.

Inspect the refrigeration compressors. If they are externally sprung, loosen the hold-downs till the compressors float freely.

Spin the condenser fan (on air cooled units) with your finger. Be sure it is free. Also make sure the conditioner fan spins freely.

Make the electrical hook-ups shown on the electrical drawing. Good idea to make your connections through a close-by disconnect. This is not Tenney supplied unless specifically ordered.

If your unit is water-cooled, connect to the water-in fitting at the rear. Connect the water-out to an open drain.

WATCH THAT LINE VOLTAGE

One of the most common causes of chamber malfunction is low line voltage at the chamber terminals. The user should be careful that his facility is connected to a circuit with adequate ampacity to handle the load. Tenney chambers are designed to operate on the following voltages with noted maximums and minimums applying to nameplate nominal:

115 volts nominal:	104v. minimum to 127v. maximum
230 volts nominal:	208v. minimum to 253v. maximum

Chambers rated 208 volts should never be operated below 200 volts as a bare minimum. If voltage falls to that level, or close to it, at maximum operation, it is strongly suggested that the chamber be fitted with a suitable

boosting transformer. Tenney will be glad to recommend and quote on the correct transformer.

PREPARATION FOR USE

No special preparation is required after the chamber is set-up, levelled, attached to its power source. It is then ready to operate on a shake-down run as described in the following paragraphs.

OPERATE THE CHAMBER AS SOON AS IT IS RECEIVED

We suggest that when this chamber is first set up and ready to run, that you operate it in various modes before using it as a test facility.

Pull the chamber down to its lowest rated temperature and allow it to stabilize for a half hour. Then heat it to its highest rated temperature, again allowing it to stabilize. Operating the chamber as described will assure that it is operable and that it was not damaged in transit.

OPERATING WITH AN ACTIVE HEAT LOAD

Remember that when testing with an active live load, such as an energized electronic assembly, its generated heat must be removed. If it is not, chamber temperature will rise. Tenney chambers are well insulated; an active heat load in the workspace will raise chamber temperature quickly unless refrigeration is available to remove the heat.

Where you perform tests on a specimen which gives off heat, and where runaway high temperature would damage its components, consider using the customer's alarm contact closure to shut down the heat-generating specimen in the event the alarm circuitry detects high temperature in the chamber.

PREVENTIVE MAINTENANCE

Since the refrigeration is sealed and the temperature controller is solid state, very little maintenance is required on the T-5 temperature chamber. However, the following preventive maintenance steps are suggested once each three months:

1. Clean the refrigeration condenser with a vacuum cleaner and brush.
(Air cooled units only).
2. Inspect and clean the condenser fan. Make sure it spins freely.
(Air cooled units only).
3. Inspect and clean the conditioner fan. Make sure it spins freely.
4. Clean the inside of the chamber with Tenney's Humiclean.
5. Inspect the door gasket, making sure the door seals well.
6. Adjust the door latch if the door does not seal well. If adjustment of the latch does not make the door close tightly, replace the gasket.
7. About once a month, examine the refrigeration system. Make sure the compressors are secure, that no wires or tubes are chaffed, that the starting components are tight.
8. If your facility has a water-cooled condenser, check water flow occasionally.
9. About once a year, inspect the inside of the power box. Look for loose connections, frayed wires and lint. If you find lint or dirt, vacuum clean the box - after shutting off all power, naturally.

IN CASE OF TROUBLE

Tenney facilities have conductors carrying dangerous voltage and with heavy current carrying capacity. Be careful when trouble-shooting.

The control switch opens the circuit to most of the controls and mode switches. However, power circuits remain hot and are dangerous unless the main disconnect switch is open.

Don't take chances. Before working on a machine, open the main disconnect switch and tag it with a red tag saying "DANGER - DO NOT CLOSE THIS SWITCH".

Our refrigeration systems are sealed and require little service. If you suspect a malfunction, write or call Tenney's Service Department. Unless you are expert in the refrigeration art, don't tamper.

Insufficient cooling, increasing vibration, compressor overheating and constant compressor loading are signs of trouble.

But Note: This Tenney facility is designed to operate with the compressor locked on continuously whenever cooling mode is selected by MicroTenn. Don't be alarmed about this.

Before writing or phoning Tenney, inspect the system superficially: Be sure the condenser is getting plenty of water or air. Make certain the cooling coils are defrosted and that power supply voltage is nominal when all systems are operating.

Should you have to contact Tenney about your refrigeration system, please jot down all the numbers on the compressor identification plate. Also give us the serial number of the chamber. This will help us give you fast service on spare parts.

Before trouble-shooting the control system, get a copy of the electrical schematic. It is included with these instructions.

Open or short circuits, inoperative relays, blown fuses or open fail safe devices are most common malfunctions.

When shooting trouble, carefully trace one system at a time. Be systematic. Use a trouble light, buzzer or volt ohmmeter. Don't carelessly tinker one circuit or system out of adjustment only to find the trouble somewhere else: Then you'll have double trouble to repair and the job will be twice more difficult.

Use the X1 scale on an ohmmeter when checking circuit continuity. Don't use X10, X100 or higher or you'll sometimes get false readings. Stray capacity, leakage and high resistance connections will falsely appear as a good circuit.

Check all breakers, overloads and manual resets. Inspect the power box. Look for burned wires, loose connections, scorched components. Pay particular attention to relay and contactor coils.

PARTS IDENTIFICATION

Component parts are shown and identified on the drawings accompanying this manual. The bills of material indicate nomenclature and part numbers to be used in ordering replacement or spare parts.

PARTS REQUISITIONING

Identified by name and part number, parts can be ordered from Service Department, Tenney Engineering, Inc., 1090 Springfield Road, Union, N. J. 07083. When parts are ordered, the serial number of the chamber must be given in addition to the nomenclature.

DANGER

THE MACHINERY COMPARTMENT HAS EXPOSED ELECTRICAL CONNECTIONS.

CAUTION

THIS IS NOT AN EXPLOSION PROOF CHAMBER. It has modern, low mass, open wire heating elements to provide close temperature control. Due to their low mass, the heater wires can reach temperatures of 1,500°F, sufficient to ignite explosive mixtures of gases or vapors in the chamber. Because of this danger, DO NOT test any product in your chamber which is capable of generating combustible mixtures.

WARNING

DISCONNECT ALL ELECTRICAL POWER FROM THE FACILITY BEFORE SERVICING OR CLEANING THE CHAMBER INTERIOR.

Addendum

Chambers having the Carling 5-pole circuit breaker 1CB

RESET AFTER POWER INTERRUPTION

On chambers having the Carling 5-pole circuit breaker as circuit breaker 1CB, pole #1 serves as the means of tripping open the breaker when the high heat cutout opens. Pole #1 replaces the trip coil formerly used in the 4-pole breaker. In the 5-pole Carling breaker, applying voltage to pole #1 causes the breaker to trip open all its poles simultaneously.

Assume that power has been off and is restored. There is the probability that the normally-closed contact in relay 2CR would immediately trip open breaker 1CB before 2CR had time to transfer. False trip-out is prevented by resistor R. This resistor limits current to the breaker's pole #1. The breaker's time constant depends upon current. Therefore by limiting current to pole #1, the breaker is delayed from opening. This gives relay 2CR ample time to transfer.

Note: Pole #1 is intended solely to trip open the breaker when an out-of-tolerance condition occurs. This pole does not protect a circuit.

TENNEY ENGINEERING, INC.
1090 SPRINGFIELD ROAD
UNION, NEW JERSEY

OPERATION OF A MICROTENN-EQUIPPED CHAMBER

CONTENTS:

	<u>Page No.</u>
Operation	1
Watchdog System	5
The Heat Limiter	7
Sensors	8
Instrumentation Fan Activation	9
Conditioner Fan Activation	10
Output for Relative Humidity Recording	11
Control Heat Modulation	12
Boost Heat Control	13
High Stage Compressor Operation	14
Low Stage Compressor Operation	15
Cooling Modulation	16
Cascade Condenser Feed	18
Ambient Coil Feed	19
Humidifier Modulation	20
Boost Humidification	21
Dehumidification Control	22
Wick Pan Feed Control	23
Humidifier Warm-Up	24
Auxiliary Checkout Instructions for Tape Operation	25
Tape Error Corrections	26
Aux. Operating Instructions for Tape Operations	27

OPERATION OF A MICROTENN-EQUIPPED CHAMBER

Please read your MicroTenn manual before attempting to operate the chamber. MicroTenn is not only a programmer, but also a controller and alarm system. The chamber cannot be operated except through proper key strokes on MicroTenn.

In this instruction, humidity is referred to from time to time. If yours is a temperature-only chamber, please disregard all references to the humidity parameter. All remarks pertaining to temperature remain valid.

Operation

1. The battery backup switch is left closed when the chamber is shipped from Tenney; therefore, the battery will be discharged and will require about 15 hours to attain full charge. However, the chamber may be used without battery backup provided there is no power interruption.

If you should want to reach the battery backup switch to check on it or to turn it off for any reason, proceed as follows:

Loosen the four knurled thumb screws on MicroTenn's front cover. Screws on the left are left-hand thread; those on the right are right-hand. Slightly lift and pull out MicroTenn. While holding the instrument, have a helper reach in behind and open or close the battery switch as required. It is a miniature toggle switch on the chamber frame at the lower right

hand of the MicroTenn opening. This switch should be left closed by the user as long as the chamber is in active use.

Note:

While removing and replacing MicroTenn, be SURE that no power is applied to the chamber. Make certain that the chamber is completely de-energized. Wiring in back of MicroTenn presents a definite shock hazard.

2. Open the circuit breaker on the side of the chamber.
3. Open the cassette door, inspecting the cassette inside. When installed with side "A," facing inward, the test program will be available. This is the test program run on the chamber on the Tenney test line and identified as 001.
4. Plug the chamber into a receptacle. The small instrument fan will run. Lights will blink in sequences on MicroTenn's displays. This means that the tape is loading information into MicroTenn. Wait about five minutes while the tape loads. The power light will be on, as will the "normal" green light.
5. When the tape finishes loading, the display will flash. The upper display should show a message, the coding of which is in the MicroTenn instruction manual. The lower display indicates tape identification. The correct tape identification is printed on the cassette

6. Turn the key switch to "Full Access".
7. Press "Clear" to clear the top display.
8. Select "Controller" on the Programmer/Controller switch.
9. Press the scroll arrow to verify channel 1 (temperature) proportional band. Correct proportional band is listed on the sheet accompanying this instruction.
10. Press "Enter" to verify channel 2 (humidity). Note: Skip this step if the chamber lacks humidity capability.
11. Press scroll arrow to verify channel 2 reset. (Humidity only.)
12. Press "Enter" to verify channel 1 (temperature) reset.
13. Press scroll arrow to verify deviation alarm.
14. Press scroll arrow to verify lower limit. This will be -100.
15. Press "Enter" to verify upper limit. This is set by Tenney at a temperature approximately 10°C above the high temperature rating of the chamber.
16. Press Programmer/Controller switch. Programmer light will flash. Lower display will indicate channel 1 (temperature) setpoint.
17. Press "Enter". Channel 2 (humidity) setpoint will appear in the lower display.
18. Press "Manual" key (the one between "Run" and "Prog.")

19. Enter desired setpoint temperature in channel 1.

20. Enter desired setpoint humidity in channel 2. (On humidity chambers only.)

21. Close the circuit breaker. This will arm the instrumentation and energize the small instrumentation fan. It will also permit the recorder to record, on chambers fitted with this option.

22. Pres controller "Auto". The chamber will now run, simulating the temperature and humidity conditions entered into its setpoints.

Note:

The procedure given here will help the new operator get the chamber into operation. However, to operate the chamber with programs and to use MicroTenn to its fullest capability, please read the accompanying MicroTenn instruction manual.

Watchdog System

Watchdog relay 1CI is shown on the schematic drawing to have one normally-open and one normally-closed contact. When circuit parameters are in safe configuration (no out of tolerance conditions) the N.O. contact is closed; the NC contact is open.

When conditions are OK, the N.O. contact energizes the green normal light, and, through heat limiter HL, energizes the coil of relay 1CR.

Relay 1CR performs two functions when energized:

1. It provides a customer's contact closure, closed when circuits are OK.
2. It opens the circuit to 1CB circuit breaker trip coil, allowing circuit breaker 1CB to remain closed.

When watchdog relay 1CI detects an out-of-tolerance condition, it transfers its contacts. Its N.C. contact now energizes the warning buzzer through switch 1SS; and the contact also energizes the red alarm light. Simultaneously, through its N.O. contact, the watchdog relay extinguishes the green normal light, and de-energizes relay 1CR. When de-energized, relay 1CR performs two functions:

1. It opens the customer's contact.
2. It energizes trip coil 1CB in the circuit breaker.

When energized, even briefly, the trip coil opens circuit breaker 1CB,

effectively shutting down the facility. Breaker 1CB will now remain open until manually reset. However, the breaker will not remain reset until the alarm condition has been cleared.

On the electrical schematic, silence switch 1SS is shown in normal position, allowing the watchdog relay to sound the buzzer when in alarm state. However, if the switch is thrown to its alternate (silence) position, the buzzer cannot be energized when the watchdog is in alarm state. In this case, the silence light will be energized.

If silence is selected on switch 1SS when the watchdog is in safe state, the buzzer will be energized through the N.O. contact in 1CI. This ringback feature reminds the operator to return the switch to its correct position.

The Heat Limiter

Heat Limiter HL is wired in series between the watchdog relay's normally-open (N.O.) contact and the coil of relay 1CR. On sensing temperature above its rating, heat limiter HL open-circuits, de-energizing relay 1CR. In response, the relay opens the customer's contact. The relay also applies voltage to the trip coil in circuit breaker 1CB. This opens the circuit breaker and shuts down the facility.

In order to re-start the facility, the operator must replace the heat limiter, then manually close the circuit breaker.

Warning

The heat limiter can be worked on only after the chamber has cooled and only when it is disconnected from all sources of power.

Sensors

MicroTenn is provided with the following sensors:

1. Platinum resistance sensor measures dry bulb temperature in the chamber. Its response is used by the instrument to control temperature in a bridge control circuit. It is also used to provide dry bulb temperature reference for the humidity controller.

2. Differential wet/dry bulb thermocouple sensor measures humidity. At high humidity the differential voltage signal is high; at low humidity the signal is low. This signal, combined with the dry bulb temperature signal gives the humidity control instrumentation its measured variable input.

3. Platinum resistance sensor measures chamber temperature, providing measured variable signal for the hi-lo alarm circuitry.

Instrumentation Fan Activation

The instrumentation fan, blowing vertically upward into the instrument compartment, is energized by 115 VAC power whenever the chamber is connected to its power source. Opening of circuit breaker 1CB does not de-energize the fan. Service persons should keep this in mind.

Conditioner Fan Activation

Switching module LSM-01 energizes the conditioner fan directly provided the fan motor is small enough to draw 3 amps or less.

Where the fan draws more than 3 amps, the switching module energizes the fan through a triac.

Switching module LSM-01 is energized by MicroTenn whenever the controller is modulating any parameter. The fan is off only when the controller is off.

Output for Relative Humidity Recording

MicroTenn measures chamber relative humidity with its differential thermocouple wet/dry sensor and its dry bulb resistance sensor.

Measured relative humidity is converted to a 0 - 5 VDC output signal which is transmitted to a recorder or digital read-out instrument.

0 VDC is equivalent to 0% RH, and 5 VDC is equivalent to 100% relative humidity.

Control Heat Modulation

Comparing measured variable chamber temperature against setpoint temperature, the MicroTenn temperature control circuit conducts when determining that chamber temperature is low. Output is time-proportioned on a 6.375 second cycle time. Percentage of on-time increases as temperature deviates farther from setpoint, provided that temperature is in the proportional band. When difference between measured and setpoint temperature is outside of the proportional band, on-time is 100%.

Proportional band is adjustable between 0% and 100%.

In signaling for control heat, MicroTenn conducts through switching module 1SM-03. This switching module triggers triac 1TIF-03 which energizes the control heater bank.

Boost Heat Control

Many chambers are fitted with one or two steps of boost heat, these systems functioning as follows:

Single step of boost heat is energized via switching module 1SM-04 when chamber temperature deviates more than 3°C below setpoint. Switching module 1SM-04 triggers triac interface 1TIF-04 which, in turn energizes boost heater bank No. 1.

Where the chamber has two steps of boost heat, the second boost step follows the first, delayed by a time capsule. The sequence is as follows: The first step is energized and operates for two minutes approximately. If, after two minutes, the heat requirement is not satisfied, the time capsule times-out, energizing the second step. When the heat requirement is satisfied, module 1SM-04 de-energizes both boost steps. If there is again a demand for boost heat, the module energizes step No. 1, then the capsule, after its delay time, energizes step No. 2. However, if the boost heat requirement is satisfied before the capsule times-out, the No. 2 heater will not respond.

High Stage Compressor Operation

When MicroTenn signals for high stage refrigeration compressor operation, it energizes switching module 1SM-06. Through a triac interface or, on larger compressors, through a line contactor, the switching module energizes the compressor.

1SM-06 conducts in response to automatic pumpdown requirement, and conducts when the low stage compressor runs. It also conducts for ambient cooling or dehumidification requirement. Minimum off-time is one minute. This protects the compressor against rapid cycling.

Low Stage Compressor Operation

When MicroTenn signals for low stage refrigeration compressor operation, it energizes switching module 1SM-05. Through a triac interface or, on larger compressors, through a line contactor, the switching module energizes the compressor.

1SM-05 conducts when the main cooling output is greater than 10%. It ceases conducting if high stage protection is open or if low stage protection is open. It is off if primary heat is greater than 50% or the change in setpoint is toward a warmer temperature.

Cooling Modulation-

On most chambers, switching module 1SM-08 opens the full main coil solenoid feed valve when the low stage compressor is running and chamber setpoint is less than 20°C. Switching module 1SM-08, when conducting, also arms the artificial loading valve control. This control opens the artificial loading valve when head pressure exceeds a preset value. On chambers using the described control system, chamber temperature is modulated by bucking time proportioned heat against fixed refrigeration.

On some larger chambers, module 1SM-08 opens the full main coil solenoid feed valve as described above. In addition, module 1SM-07 operates the main coil solenoid feed valve on a time proportioned cooling cycle of 6.375 seconds. This is operated by the temperature control circuitry which also proportions heat, as described elsewhere. Between heating and cooling, there is a 1% dead band preventing the two functions from bucking each other. On a temperature/humidity chamber, output of 1SM-07 is off when the high stage compressor is off. On a temperature chamber, 1SM-07 is off when the low stage compressor is off.

The artificial loading solenoid valve is opened by switching module 1SM-09 on a time proportioned basis complementary to the main cooling coil valve. In other words, the loading valve opens when the coil

feed valve closes, and vice versa. Purpose of the artificial loading valve is to provide sufficient mass flow in the refrigeration system when the coil is not being fed. On temperature chambers, LSM-09 is off when the low stage compressor is off. On temperature/humidity chambers, it is off when the high stage compressor is off.

Cascade Condenser Feed

The cascade condenser uses high stage refrigerant to condense the low stage. High stage refrigerant is admitted to the condenser (which is a heat exchanger) on command from switching module LSM-10 which opens the solenoid valve. The module conducts if high pressure cutout is closed or low stage compressor is running.

Ambient Coil Feed

The ambient coil feed solenoid valve is operated by switching module 2SM-11. Purpose of the ambient coil is to cool the chamber at moderate temperatures, and to cool humidity chambers when humidity is being controlled.

Module 2SM-11 conducts if the main cooling coil output is greater than 10%. It ceases conducting if main cooling coil output is less than 10% and primary (control) heat output is greater than 50%. It ceases conducting if temperature setpoint is greater than chamber temperature.

Humidifier Modulation

Comparing measured variable chamber humidity against setpoint humidity, MicroTenn's humidity control circuit conducts when determining that chamber humidity is low.

Output is time proportioned on a 6.375 second cycle time, and output is through switching module 2SM-12 which triggers triac 2TIF-12. The triac energizes the humidifier's immersion heater. Percentage of on-time increases as humidity deviates farther from setpoint, provided that humidity is in the proportional band. When difference between measured and setpoint humidity is outside of the proportional band, on-time is 100%.

Boost Humidification

Some rooms and a few of the largest chambers have boost humidification. The boost humidifier is energized by switching module 2SM-13 through either a triac or line contactor. Boost is energized when chamber humidity deviates more than 5% below setpoint.

Dehumidification Control

On detecting the need for dehumidification, the humidity control circuitry energizes the dehumidification solenoid valve through switching module 2SM-14. The solenoid valve admits refrigerant to the coil.

Module 2SM-14 conducts if chamber humidity is measured greater than 6.1% of setpoint. The module ceases conducting when deviation is less than 6.1% and time proportioned humidity control is greater than 50%, or humidity is lower than setpoint.

Wick Pan Feed Control

When the chamber is simulating humidity conditions, the wick pan feed water solenoid valve is energized by switching module 2SM-16. The switching module operates the valve directly.

Humidifier Warm-Up

An adjustable thermostat in the humidifier's steam generating bell jar enclosure monitors water temperature. The thermostat is typically set at about 80° C., and when it detects water temperature below this setting, it completes a circuit to MicroTenn. In response, MicroTenn energizes the humidifier heater until thermostat setpoint water temperature is restored.

Purpose of the "keeper" circuit is to maintain humidifier water reasonably close to boiling so that response lag will be minimized when the controller first signals for humidification.

When the chamber is operated in the temperature-only mode, the humidifier is allowed to remain at ambient temperature.

AUXILLIARY CHECKOUT INSTRUCTIONS FOR TAPE OPERATIONS

READ OPERATIONS (INCLUDING POWER UP)

1. Do not interrupt power to the Microtenn while the unit is attempting to read the tape.
2. If unit fails to achieve a proper operating status on power up, remove the tape before powering the unit down.
3. Do not open door while a read is being attempted unless unit rewinds to start and attempts to read tape again, indicating a failed read attempt. Unit has also not successfully completed the read if the displays are blank after tape has rewound or the "E8" error codes are displayed. Refer to the error correction section below if these occur.
4. Cycling of the drive during a read does not necessarily indicate that a read error has occurred. See the notes above for the definite characteristics of an error.

WRITE OPERATIONS

1. Do not interrupt power to the Microtenn while the unit is attempting to write to the tape.
2. Do not disturb unit (Open door, jar unit, etc.) for any reason during a write operation.
3. Verify immediately that the write operation was successful. If a profile was added, attempt to re-read the profile. If an "E8-01" error occurs re-write the profile to the tape. If an operating system change was made, remove the tape from the Microtenn that the modifications were completed on and transfer to a testing unit. Re-initialize this unit with the new tape and test the characteristics of the new operating system. If problems occur, return the tape to the original Microtenn and re-write the system. Repeat the test if necessary.

TAPE ERROR CORRECTIONS

- 1) To begin the correction, the unit must be re-initialized with an error free operating system. Apply power to the unit and insert an error-free tape in the drive. The reverse side of the damaged tape is acceptable for this. When the Microtenn has loaded this tape (side), remove it and reinsert the tape (side) with the error.
- 2) Press the "PROG ID" key. This causes the unit to read the tape library. If the tape error is in the library, the unit will respond with an error message "E8-01". If this is the case, the side with the error can not be corrected.
- 3) If the "PROG ID" function is accepted, the error is in the profile or system areas. Scroll through the library (using the procedure in the manual) and make a note of the profile ID numbers in the library.
- 4) Read the profiles into the Microtenn one by one until all have been tested or an "E8-01" error occurs.
- 5) If an error occurs while reading a profile this profile will have to be rebuilt. The first step is to delete the profile from the tape library following the procedure in the manual. Next, a profile must be written to the tape. The user may regenerate the profile that was stored here or use the default profile in memory. The profile ID number does not have to be the same as the deleted profile. When this is completed, repeat step 5) until all profiles have been examined for errors.
- 6) If the library contained less than ten profiles, the user must write "dummy" profiles to the tape until the library is full. This insures that the entire profile area is error free. Any profile ID numbers may be used. Using the default values already in the memory is the easiest method. These profiles may be deleted when this step is complete.
- 7) This tape should be loaded to a separate unit to determine if all the errors have been corrected. If all errors were in the profile area of the tape, the tape should now load correctly. If not, continue with step 8).
- 8) Return the tape to the original Microtenn and write the operating system to the tape using the procedure in the manual.
- 9) Re-initialize the unit with the corrected tape to check all corrections.

INSERT FOR TENNEY USER MANUAL

AUXILLIARY OPERATING INSTRUCTIONS FOR
TAPE OPERATIONS

READ OPERATIONS
(INCLUDING POWER UP)

1. Do not interrupt power to the Microtenn while the unit is attempting to read the tape.
2. If unit fails to achieve a proper operating status on power up, remove the tape before powering the unit down.
3. Do not open door while a read is being attempted unless unit rewinds to start and attempts to read tape again, indicating a failed read attempt. Unit has also not successfully completed the read if the displays are blank after tape has rewound or the "E8" error codes are displayed. Refer to the error correction section below if these occur.
4. Cycling of the drive during a read does not necessarily indicate that a read error has occurred. See the notes above for the definite characteristics of an error.

WRITE OPERATIONS

1. Do not interrupt power to the Microtenn while the unit is attempting to write to the tape.
2. Do not disturb unit (Open door, jar unit, etc.) for any reason during a write operation.
3. Verify immediately that the write operation was successful. This action is dependent on which write operation was attempted. If a profile was written, the operator should attempt to re-load that profile. If this fails, redo the write operation and verify that the profile is now saved correctly.
4. If an operating system was modified, the operator should verify the new system was written correctly. Re-load the operating system from the keyboard following the procedure in the manual (see "READ TAPE PROCEDURES" section). If the tape fails to re-load correctly (see Read operations above), refer to the error correction section below.

TENNEY TEMPGARD II INSTRUCTIONS

(TempGard, With Circuit Breaker Reset, Used On Standard Chamber)

SCOPE

These instructions apply to the Tenney TempGard II temperature protective instrument used on standard instrumentation and control panels. Both the high and low cutouts are covered. Where a high-only instrument is involved, remarks applying to the low circuit can be disregarded.

DRAWINGS

Drawings applying to the TempGard II are included with this instruction set.

PARTS LISTS

Complete parts lists are found in the bills of material which comprise part of the drawings.

THEORY OF OPERATION

Individual thermocouples serve the high temperature and low temperature printed circuit cards. The cards are shown on the electrical schematic as AR1 and AR2. On detecting temperature above set-point, card AR1 transfers its relay AR1. Its NC contact energizes the alarm light and buzzer.

The low temperature cutout card functions the same as the high except that response is conditioned to the thermocouple sensing temperature colder than set-point temperature. Relay AR2 and R5 perform the (low) functions performed by AR1 for the high.

Thermocouple break protection is included. Should either thermocouple connection be broken, the affected card will immediately transfer

to alarm condition.

In the event of power failure, the instrument will transfer to alarm condition but will be reset automatically by R4 when power is restored. Its NO contact deenergizes the coil of relay R1 in the chamber's standard instrumentation panel. When deenergized, relay R1, through its normally-closed contact, applies voltage to the trip coil in circuit breaker CBI (control circuit breaker) disabling the controls and shutting down the chamber's conditioning.

When workspace temperature returns to within tolerance, TempGard is reset by the 4-pole circuit breaker serving the chamber's control circuits. When the handle on this breaker is returned to closed position, the breaker momentarily applies voltage, through a short time-delay relay, to the coil of relay R4. By its NC contacts, relay R4 resets TempGard, restoring conditioning by allowing the circuit breaker to remain closed.

DISABLING AN ACTIVE HEAT LOAD

Where an active heat load, such as an energized electrical assembly, is being tested in the chamber, it is often desirable to deenergize the active load when TempGard high transfers to alarm condition. This is easily done.

Relay R1, in the chamber's power box, is deenergized when TempGard is in alarm condition. This relay's normally-open contacts are made available for energizing customer's active heat load, and are connected to terminals 48 and 49 in the power and control box. To reach the terminals, the installer removes the 18" x 24" sheet metal panel covering the power

components. Inside he will find a long terminal strip with numbered terminals. The hot side of his power feed to the specimen is wired in series with these terminals (which represent the two NO contacts in relay R1). Maximum rating of the relay contacts is 10 amps resistive.

Connected as described, the test specimen will be deenergized when TempGard transfers to alarm state, when the heat limiter HL opens, or when control power is removed from the instrumentation circuit.

SWITCH FUNCTIONS DESCRIBED

The following describes the function of the two switches on the front of TempGard II:

SW1 POWER switch is the master switch which energizes the entire unit. This switch must be closed in order for the TempGard to function. Momentary opening and closing of this switch will transfer the instrument to alarm condition. It must then be reset by opening and closing of the control circuit breaker CBI on the chamber.

SW2 SILENCE switch quiets the high frequency buzzer when TempGard is in alarm state. There is a ring-back feature to remind the operator to reset the switch. When "silence" is selected, the buzzer will sound when the instrument is in safe configuration. In other words, the silence switch reverses the buzzer function.

THE PILOT LIGHTS

The following describes what is indicated as each pilot light glows:

PL1 (Red) Alarm: The TempGard is in alarm state. (Workspace temperature may have returned to within set-point tolerance, but the

device will remain in alarm state, light on, until reset.)

PL2 (Amber) Silence: "Silence" is selected on the switch. Buzzer function is reversed.

PL3 Normal: Temperature is within tolerance and the instrument is in safe state with relay R1 energized, buzzer off, red light off.

A PRECAUTION WHERE TESTING INCLUDES A LIVE LOAD

If the TempGard II is used to protect specimens which generate heat (such as active electronic equipment) take this into account when wiring the active load. For maximum protection, energize the live specimens via the TempGard II as described earlier. Then, if the TempGard detects out-of-tolerance high temperature, it will disable the specimens as well as shutting down the test facility. (Under some circumstances, the user may want to place the TempGard thermocouple in the test specimen rather than in the workspace.)

USING YOUR TEMPGARD II

Set the high temperature set-point dial at a temperature above the operating temperature of the protected workspace. Set the low temperature dial to a lower temperature than that of the workspace. If the workspace temperature is programmed, set the TempGard's low and high set-points to a wider range of temperatures than those programmed. Otherwise, the instrument may shut down the main facility on a false alarm.

Close the power switch; then close the control circuit breaker.

TempGard II will now energize its protected circuits and the green "Normal" light will glow.

ADJUSTING SET-POINT BY ACTUAL TEMPERATURE

Set-point can be adjusted to temperature more accurate than that indicated on the printed dial by the actual temperature method. Adjust the TempGard II High as follows:

1. Set the dial at 425° F. Condition the chamber to desired high set-point.
2. With the TempGard energized, very slowly rotate the high set-point dial down toward set-point until the instrument clicks to alarm state. It now has the set-point of chamber temperature.

TempGard II Low is adjusted in the same way, except that the dial is rotated upscale from -125° F until the instrument clicks to alarm condition.

To avoid temperature offset, it is important that the dial be moved very slowly when approaching set-point.

CHECKOUT PROCEDURE

The unit was carefully tested at Tenney and should require no further calibration or test. However, for reference, the Tenney checkout procedure is included with this instruction set.

PARTS AND SERVICE

Tenney offers parts and service for TempGard II. When phoning or writing the company, please cite the unit's serial number.

TEMPGARD II CHECKOUT

Serial No. _____

FUNCTIONAL CHECKOUT

Note: The following procedure is written for Hi-Lo units. For Hi only units ignore references to Lo.

Twist TC (hot ends together).
Silence and Power switch off.
High set point full clockwise.
Low set point full counter-clockwise.
Connect unit to 115V source.
Select Power switch.

Alarm light on.
Hi Normal light on (dimly)
Buzzer on.

Select Silence:

Buzzer off.
Silence light on.

Turn off Silence switch:

Buzzer off.
Silence light off.

Turn Hi Pot Downscale:

Alarm light on.
Hi Normal light off.
Buzzer on.

Select Silence:

Buzzer off.

Turn Hi Pot Upscale:
Reset by a jumper

Alarm light off.
Hi Normal light on.
Buzzer on.

Turn Off Silence Switch:

Buzzer off.

Turn Lo Pot Upscale:

Alarm light on.
Lo Normal light off.
Buzzer on.

Select Silence:

Buzzer off.

Turn Lo Pot Downscale:
Reset by a jumper

Alarm light off.
Normal light on.
Buzzer on.

Turn Silence Switch Off.

Buzzer off.

Check Calibration and Zero-Adjust
Pot knob for minimum error
TC junctions welded

Checked and calibrated _____ Date _____

Approved _____

MINCO

RESISTANCE TEMPERATURE TABLE U.S. INDUSTRIAL SPEC. R 100C / R_{0C} = 1.3911 PLATINUM RESISTANCE THERMOMETER 100 OHMS AT 0°C.

TABLE 11-100

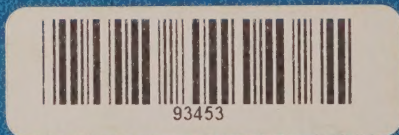
7300 Commerce Lane | Minneapolis, Minnesota 55432 | TWX: 910-576-2848 | Telephone: (612) 786-3121

T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)
-200.0	17.26	-155.0	36.67	-110.0	55.51	-65.0	73.93
-199.0	17.70	-154.0	37.09	-109.0	55.93	-64.0	74.34
-198.0	18.14	-153.0	37.52	-108.0	56.34	-63.0	74.74
-197.0	18.58	-152.0	37.94	-107.0	56.75	-62.0	75.15
-196.0	19.01	-151.0	38.37	-106.0	57.17	-61.0	75.55
-195.0	19.45	-150.0	38.79	-105.0	57.58	-60.0	75.96
-194.0	19.89	-149.0	39.21	-104.0	57.99	-59.0	76.36
-193.0	20.32	-148.0	39.63	-103.0	58.40	-58.0	76.77
-192.0	20.76	-147.0	40.06	-102.0	58.81	-57.0	77.17
-191.0	21.20	-146.0	40.48	-101.0	59.23	-56.0	77.58
-190.0	21.63	-145.0	40.90	-100.0	59.64	-55.0	77.98
-189.0	22.07	-144.0	41.32	-99.0	60.05	-54.0	78.39
-188.0	22.50	-143.0	41.74	-98.0	60.46	-53.0	78.79
-187.0	22.94	-142.0	42.16	-97.0	60.87	-52.0	79.19
-186.0	23.37	-141.0	42.59	-96.0	61.28	-51.0	79.60
-185.0	23.80	-140.0	43.01	-95.0	61.69	-50.0	80.00
-184.0	24.24	-139.0	43.43	-94.0	62.10	-49.0	80.40
-183.0	24.67	-138.0	43.85	-93.0	62.51	-48.0	80.81
-182.0	25.10	-137.0	44.27	-92.0	62.92	-47.0	81.21
-181.0	25.54	-136.0	44.69	-91.0	63.33	-46.0	81.61
-180.0	25.97	-135.0	45.10	-90.0	63.74	-45.0	82.01
-179.0	26.40	-134.0	45.52	-89.0	64.15	-44.0	82.42
-178.0	26.83	-133.0	45.94	-88.0	64.56	-43.0	82.82
-177.0	27.26	-132.0	46.36	-87.0	64.97	-42.0	83.22
-176.0	27.69	-131.0	46.78	-86.0	65.38	-41.0	83.62
-175.0	28.12	-130.0	47.20	-85.0	65.79	-40.0	84.03
-174.0	28.55	-129.0	47.62	-84.0	66.20	-39.0	84.43
-173.0	28.98	-128.0	48.03	-83.0	66.61	-38.0	84.83
-172.0	29.41	-127.0	48.45	-82.0	67.02	-37.0	85.23
-171.0	29.84	-126.0	48.87	-81.0	67.42	-36.0	85.63
-170.0	30.27	-125.0	49.28	-80.0	67.83	-35.0	86.03
-169.0	30.70	-124.0	49.70	-79.0	68.24	-34.0	86.43
-168.0	31.13	-123.0	50.12	-78.0	68.65	-33.0	86.84
-167.0	31.56	-122.0	50.53	-77.0	69.06	-32.0	87.24
-166.0	31.98	-121.0	50.95	-76.0	69.46	-31.0	87.64
-165.0	32.41	-120.0	51.37	-75.0	69.87	-30.0	88.04
-164.0	32.84	-119.0	51.78	-74.0	70.28	-29.0	88.44
-163.0	33.27	-118.0	52.20	-73.0	70.68	-28.0	88.84
-162.0	33.69	-117.0	52.61	-72.0	71.09	-27.0	89.24
-161.0	34.12	-116.0	53.03	-71.0	71.50	-26.0	89.64
-160.0	34.54	-115.0	53.44	-70.0	71.90	-25.0	90.04
-159.0	34.97	-114.0	53.86	-69.0	72.31	-24.0	90.44
-158.0	35.40	-113.0	54.27	-68.0	72.72	-23.0	90.84
-157.0	35.82	-112.0	54.68	-67.0	73.12	-22.0	91.24
-156.0	36.25	-111.0	55.10	-66.0	73.53	-21.0	91.64

T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)
-20.0	92.04	25.0	109.89	70.0	127.50	115.0	144.87
-19.0	92.44	26.0	110.28	71.0	127.89	116.0	145.26
-18.0	92.84	27.0	110.67	72.0	128.28	117.0	145.64
-17.0	93.24	28.0	111.07	73.0	128.66	118.0	146.02
-16.0	93.63	29.0	111.46	74.0	129.05	119.0	146.41
-15.0	94.03	30.0	111.86	75.0	129.44	120.0	146.79
-14.0	94.43	31.0	112.25	76.0	129.83	121.0	147.17
-13.0	94.83	32.0	112.64	77.0	130.22	122.0	147.55
-12.0	95.23	33.0	113.03	78.0	130.60	123.0	147.94
-11.0	95.63	34.0	113.43	79.0	130.99	124.0	148.32
-10.0	96.02	35.0	113.82	80.0	131.38	125.0	148.70
-9.0	96.42	36.0	114.21	81.0	131.77	126.0	149.08
-8.0	96.82	37.0	114.61	82.0	132.15	127.0	149.47
-7.0	97.22	38.0	115.00	83.0	132.54	128.0	149.85
-6.0	97.62	39.0	115.39	84.0	132.93	129.0	150.23
-5.0	98.01	40.0	115.78	85.0	133.32	130.0	150.61
-4.0	98.41	41.0	116.18	86.0	133.70	131.0	150.99
-3.0	98.81	42.0	116.57	87.0	134.09	132.0	151.37
-2.0	99.21	43.0	116.96	88.0	134.48	133.0	151.76
-1.0	99.60	44.0	117.35	89.0	134.86	134.0	152.14
0.0	100.00	45.0	117.74	90.0	135.25	135.0	152.52
1.0	100.40	46.0	118.13	91.0	135.64	136.0	152.90
2.0	100.79	47.0	118.53	92.0	136.02	137.0	153.28
3.0	101.19	48.0	118.92	93.0	136.41	138.0	153.66
4.0	101.59	49.0	119.31	94.0	136.79	139.0	154.04
5.0	101.98	50.0	119.70	95.0	137.18	140.0	154.42
6.0	102.38	51.0	120.09	96.0	137.57	141.0	154.80
7.0	102.78	52.0	120.48	97.0	137.95	142.0	155.18
8.0	103.17	53.0	120.87	98.0	138.34	143.0	155.56
9.0	103.57	54.0	121.26	99.0	138.72	144.0	155.94
10.0	103.96	55.0	121.65	100.0	139.11	145.0	156.32
11.0	104.36	56.0	122.04	101.0	139.49	146.0	156.70
12.0	104.75	57.0	122.43	102.0	139.88	147.0	157.08
13.0	105.15	58.0	122.82	103.0	140.26	148.0	157.46
14.0	105.55	59.0	123.21	104.0	140.65	149.0	157.84
15.0	105.94	60.0	123.60	105.0	141.03	150.0	158.22
16.0	106.34	61.0	123.99	106.0	141.42	151.0	158.60
17.0	106.73	62.0	124.38	107.0	141.80	152.0	158.98
18.0	107.13	63.0	124.77	108.0	142.19	153.0	159.36
19.0	107.52	64.0	125.16	109.0	142.57	154.0	159.74
20.0	107.92	65.0	125.55	110.0	142.95	155.0	160.12
21.0	108.31	66.0	125.94	111.0	143.34	156.0	160.50
22.0	108.70	67.0	126.33	112.0	143.72	157.0	160.87
23.0	109.10	68.0	126.72	113.0	144.11	158.0	161.25
24.0	109.49	69.0	127.11	114.0	144.49	159.0	161.63

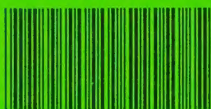
T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)	T (C)	R (OHMS)
160.0	162.01	205.0	178.91	250.0	195.57	295.0	212.00
161.0	162.39	206.0	179.28	251.0	195.94	296.0	212.36
162.0	162.77	207.0	179.66	252.0	196.31	297.0	212.73
163.0	163.14	208.0	180.03	253.0	196.68	298.0	213.09
164.0	163.52	209.0	180.40	254.0	197.04	299.0	213.45
165.0	163.90	210.0	180.77	255.0	197.41	300.0	213.81
166.0	164.28	211.0	181.15	256.0	197.78	301.0	214.17
167.0	164.65	212.0	181.52	257.0	198.15	302.0	214.54
168.0	165.03	213.0	181.89	258.0	198.51	303.0	214.90
169.0	165.41	214.0	182.26	259.0	198.88	304.0	215.26
170.0	165.79	215.0	182.63	260.0	199.25	305.0	215.62
171.0	166.16	216.0	183.01	261.0	199.61	306.0	215.98
172.0	166.54	217.0	183.38	262.0	199.98	307.0	216.34
173.0	166.92	218.0	183.75	263.0	200.34	308.0	216.70
174.0	167.29	219.0	184.12	264.0	200.71	309.0	217.06
175.0	167.67	220.0	184.49	265.0	201.08	310.0	217.42
176.0	168.05	221.0	184.86	266.0	201.44	311.0	217.79
177.0	168.42	222.0	185.23	267.0	201.81	312.0	218.15
178.0	168.80	223.0	185.60	268.0	202.17	313.0	218.51
179.0	169.17	224.0	185.98	269.0	202.54	314.0	218.87
180.0	169.55	225.0	186.35	270.0	202.90	315.0	219.23
181.0	169.93	226.0	186.72	271.0	203.27	316.0	219.59
182.0	170.30	227.0	187.09	272.0	203.64	317.0	219.95
183.0	170.68	228.0	187.46	273.0	204.00	318.0	220.31
184.0	171.05	229.0	187.83	274.0	204.37	319.0	220.67
185.0	171.43	230.0	188.20	275.0	204.73	320.0	221.03
186.0	171.80	231.0	188.57	276.0	205.09	321.0	221.38
187.0	172.18	232.0	188.94	277.0	205.46	322.0	221.74
188.0	172.55	233.0	189.31	278.0	205.82	323.0	222.10
189.0	172.93	234.0	189.68	279.0	206.19	324.0	222.46
190.0	173.30	235.0	190.05	280.0	206.55	325.0	222.82
191.0	173.68	236.0	190.42	281.0	206.92	326.0	223.18
192.0	174.05	237.0	190.78	282.0	207.28	327.0	223.54
193.0	174.43	238.0	191.15	283.0	207.64	328.0	223.90
194.0	174.80	239.0	191.52	284.0	208.01	329.0	224.26
195.0	175.18	240.0	191.89	285.0	208.37	330.0	224.61
196.0	175.55	241.0	192.26	286.0	208.74	331.0	224.97
197.0	175.93	242.0	192.63	287.0	209.10	332.0	225.33
198.0	176.30	243.0	193.00	288.0	209.46	333.0	225.69
199.0	176.68	244.0	193.37	289.0	209.82	334.0	226.05
200.0	177.05	245.0	193.74	290.0	210.19	335.0	226.40
201.0	177.42	246.0	194.10	291.0	210.55	336.0	226.76
202.0	177.79	247.0	194.47	292.0	210.91	337.0	227.12
203.0	178.16	248.0	194.84	293.0	211.28	338.0	227.48
204.0	178.54	249.0	195.21	294.0	211.64	339.0	227.83

T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)	T(C)	R(OHMS)
340.0	228.19	385.0	244.14	430.0	259.86	475.0	275.34
341.0	228.55	386.0	244.50	431.0	260.21	476.0	275.68
342.0	228.91	387.0	244.85	432.0	260.55	477.0	276.02
343.0	229.26	388.0	245.20	433.0	260.90	478.0	276.36
344.0	229.62	389.0	245.55	434.0	261.25	479.0	276.70
345.0	229.98	390.0	245.90	435.0	261.59	480.0	277.05
346.0	230.33	391.0	246.25	436.0	261.94	481.0	277.39
347.0	230.69	392.0	246.60	437.0	262.28	482.0	277.73
348.0	231.04	393.0	246.96	438.0	262.63	483.0	278.07
349.0	231.40	394.0	247.31	439.0	262.98	484.0	278.41
350.0	231.76	395.0	247.66	440.0	263.32	485.0	278.75
351.0	232.11	396.0	248.01	441.0	263.67	486.0	279.09
352.0	232.47	397.0	248.36	442.0	264.01	487.0	279.43
353.0	232.82	398.0	248.71	443.0	264.36	488.0	279.77
354.0	233.18	399.0	249.06	444.0	264.70	489.0	280.11
355.0	233.54	400.0	249.41	445.0	265.05	490.0	280.45
356.0	233.89	401.0	249.76	446.0	265.39	491.0	280.79
357.0	234.25	402.0	250.11	447.0	265.74	492.0	281.13
358.0	234.60	403.0	250.46	448.0	266.08	493.0	281.47
359.0	234.96	404.0	250.81	449.0	266.43	494.0	281.80
360.0	235.31	405.0	251.16	450.0	266.77	495.0	282.14
361.0	235.67	406.0	251.51	451.0	267.11	496.0	282.48
362.0	236.02	407.0	251.86	452.0	267.46	497.0	282.82
363.0	236.37	408.0	252.21	453.0	267.80	498.0	283.16
364.0	236.73	409.0	252.56	454.0	268.15	499.0	283.50
365.0	237.08	410.0	252.90	455.0	268.49	500.0	283.84
366.0	237.44	411.0	253.25	456.0	268.83	501.0	284.18
367.0	237.79	412.0	253.59	457.0	269.18	502.0	284.52
368.0	238.15	413.0	253.95	458.0	269.52	503.0	284.85
369.0	238.50	414.0	254.30	459.0	269.86	504.0	285.19
370.0	238.85	415.0	254.65	460.0	270.21	505.0	285.53
371.0	239.21	416.0	255.00	461.0	270.55	506.0	285.87
372.0	239.56	417.0	255.34	462.0	270.89	507.0	286.20
373.0	239.91	418.0	255.69	463.0	271.24	508.0	286.54
374.0	240.27	419.0	256.04	464.0	271.58	509.0	286.88
375.0	240.62	420.0	256.39	465.0	271.92	510.0	287.22
376.0	240.97	421.0	256.74	466.0	272.26	511.0	287.56
377.0	241.33	422.0	257.08	467.0	272.61	512.0	287.89
378.0	241.68	423.0	257.43	468.0	272.95	513.0	288.23
379.0	242.03	424.0	257.78	469.0	273.29	514.0	288.56
380.0	242.38	425.0	258.13	470.0	273.63	515.0	288.90
381.0	242.74	426.0	258.47	471.0	273.97	516.0	289.24
382.0	243.09	427.0	258.82	472.0	274.32	517.0	289.57
383.0	243.44	428.0	259.17	473.0	274.66	518.0	289.91
384.0	243.79	429.0	259.51	474.0	275.00	519.0	290.25



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1090 Springfield Rd. P. O. Box 3142, Union, New Jersey 07083

(201) 686-7870 • (212) 962-0332